



KHAYYAM, OMAR XV. AS ASTRONOMER

Despite the intrinsic importance of the works of Omar Khayyam in philosophy and in particular mathematics, as well as the worldwide renown of his *Rubaiyat*, Khayyam certainly owes much of his reputation among Iranians to his role in establishing the Jalāli calendar (see CALENDAR ii. IN THE ISLAMIC PERIOD), and it is surprising that there is not much information in early sources about Khayyam's role in this regard.

The inconvenience of the Arabian novilunar year (12 lunar months and without any intercalation, i.e., the insertion of an additional/13th lunar month into the ordinary/normal year) or the Persian vague year (the year in the modern Zoroastrian calendar, 365 days without any intercalation, i.e., the insertion of an additional/13th "30 day month" each 120-124 years; see Taqizadeh, 1940, p. 108) for practical purposes in the life of the individual and still more in social life (especially the time for collecting land taxes, *karāj*) led the Saljuq sultan Malekšāh (q.v.; r. 1072-92) and his vizier Neẓām-al-Molk Ṭusi (q.v.; 1018-92) to look for a solution. They assembled a number of the most prominent astronomers of their time to make observations of the sun and determine the time of the vernal (spring) equinox and, based on their observations, to establish a new time-reckoning (Ger. *Zeitrechnung*; Pers. *gāh-šomārī*, see Taqizadeh, 1940, p. 107) in which the beginning of the year will always be in sync with a displacement of less than twelve hours from the vernal equinox.



According to a number of astronomers and historians, including ‘Abd-al-Raḥmān Kāzeni (q.v., late 11th-mid 12th centuries), a well-known astronomer and physicist and a contemporary of Khayyam, in his *al-Zij al-mo‘tabar al-sanjari* (lit. “the reliable astronomical tables dedicated to [Sultan] Sanjar”; fols. 105r, 122v and also in an extract of this *Zij* called *Wajiz al-zij*) and Ebn al-Aṭir (q.v.; 1160-1233; X, p. 97; Abu’l-Fedā’, IV, p. 101; see also Sayılı, pp. 161, 164), the decree to amend the calendar and to summon the astronomers was issued in 467/1075.

Kāzeni (regarded by Moḥiṭ Ṭabāṭabā’i, pp. 689-92, as the founder of the Jalāli calendar), whose astronomical table (*Zij*) is our oldest source about the Jalāli calendar, in his more or less brief references to the subject, failed to mention any of those who were involved in this project or the place the observations were made. Moḥammad b. Ayyub Ḥāseb Ṭabari (d. after 1092) in his *Zij-e mofrad* considers the place of observations to be Isfahan (pp. 71-72).

Zahir-al-Din Bayhaqī (q.v.; 1097-1169), in his *Tatemmat Šewān al-ḥekma*, along with the biography of Moḥammad b. Aḥmad Ma‘muri, has a brief mention of the observations in Isfahan. According to him, Ma‘muri—whose expertise in physics and the construction of mechanical devices (*ḥeyal*) was known to Khayyam—went to Isfahan to participate in the observations decreed by Malekšāh (Bayhaqī, p. 163; Pers. tr. pp. 95-96; Eng. tr. p. 198). With the exception of this, Bayhaqī makes no mention of the observations that took place in Malekšāh’s time or Khayyam’s participation in these observations or amending of the calendar. But considering what is said about Ma‘muri and comparing it with other sources, it can be assumed that he traveled to Isfahan at Khayyam’s suggestion in order to build the required instruments for observations.

A number of contemporary researchers, regardless of the sources mentioned, have determined that the observations were carried out in Nishapur, Ray, and even Marv (Suter, p. 113; Sarton, I, p. 760; Sayılı, pp. 162–64). But in addition to what has been said, the phrase contained in the *Nowruz-nāma*, a Persian treatise attributed to Khayyam, about Malekšāh’s decree summoning the contemporaneous learned authorities from Khorasan (p. 12, “*befarmud tā ... ḥokamā’-e ‘ašr az Korāsān biāvarand*”) also indicates that these observations were carried out outside of greater Khorasan.

Ebn al-Aṭir, when describing the notable events of 467/1075 in his *al-Kāmel fi’l-ta’riḳ* (completed in 628/1231), presented “the decision to the establishment of



the Jalāli calendar” and “the observations that took place during Malekšāh reign” in two consecutive but presumably separate reports. In the first report, there is no mention of those involved in the project to amend the calendar: “In this year, Neẓām-al-Molk and sultan Malekšāh summoned a number of the most prominent astronomers, and they placed Nowruz [q.v.] on the first point of Aries [*Ḥamal*; i.e., the vernal equinox]. Before that, Nowruz coincided with the arrival of the sun to the mid-point of Pisces [*Ḥut*; i.e., the first day of the Yazdegerdi year, falling in the middle of Esfand, the twelfth month of the solar Hejri (*Hejri-ešamsi*) calendar, the current official calendar in Iran, equivalent to the first ten days of March in the Gregorian calendar]. The sultan made what they had determined the basis for the calendars” (Ebn al-Aṭir, X, p. 97).

In the second report, Ebn al-Aṭir (X, pp. 97-98) states: “And also in the same year, the astronomical observations for Malekšāh were carried out. A number of the most prominent astronomers congregated to conduct them, including ‘Omar b. Ebrāhim al-Ḳayyāmi [Khayyam], Abu’l-Mozaffar Asfezāri [Abu Ḥātem Asfezāri; q.v.], Maymun b. al-Najib al-Wāseṭi, and others. The sultan spent a great amount of money on this project and the observations continued until Malekšāh’s death in 485/1092 and were abandoned after his death.” However, it is implausible to suggest that the leading astronomers who assembled to participate in astronomical observations were not the selfsame ones summoned to amend the calendar, both by the decree of Malekšāh, especially given the level of astronomical expertise required to determine the time of the vernal equinox. (Cf. Abu’l-Fedā’, IV, 101, who refers to Asfezāri as Abu’l-Mozaffar Esfarā’eni; Neẓāmi ‘Aruzi in the *Čahār maqāla* [q.v.] claims to have met Abu Ḥātem Asfezāri in the company of Omar Khayyam at Balk in 506/1112-13 [p. 100; Eng. tr. Browne, p. 71, 137]).

Zakariyā’ b. Moḥammad Qazvini (q.v.; 1203-83) in the “fourth climate” of his *Āṭāral-belād* (q.v.), when he mentions Khayyam among the prominent figures of Nishapur, makes the following remarks: “In the reign of the Saljuq sultan Malekšāh, a great amount of wealth was given to him [Khayyam] so that he might procure astronomical instruments for observing the stars, but with the death of the sultan the task was abandoned” (II, p. 318).

Qoṭb-al-Din Širāzi (q.v.; 1236-1311) in his three astronomical works is the first to give a great insight into the role of Khayyam in establishing the Jalāli calendar: “As for the *Tāriḳ-e maleki* [i.e., Jalāli calendar and era], it is associated with the Saljuq sultan Jalāl-al-Dawla Malekšāh b. Alp Arsalān, which came about when a number of sages [*ḥokamā*], such as ‘Omar Ḳayyām



and Ḥakim Abu'l-‘Abbās Lokari and six others gathered in his court, and founded a calendar that began [its year] with the sun reaching the [first point of] Aries. And the first day of the [Jalāli] year is the first day in which, at solar noon [or high noon, i.e., the moment when the sun contacts the observer’s meridian], the sun is in Aries. And this day is called Royal Nowruz” (*nowruz-e solṭāni*; Qoṭb-al-Din Širāzi, *Ektiārāt-e moẓaffari*, 3rd *maqāla*, 11th *bāb*, fol. 149 v; *al-Toḥfa al-šāhiya*, 3rd *bāb*, 11th *faṣl*, fol. 131r; *Nehāyat al-edrāk*, 3rd *maqāla*, 10th *bāb*, fols. 154v-155r).

Mollā Moẓaffar Gonābādi (d. 1622) presents a different account that, unlike the three reports by Qoṭb-al-Din, refers by name to Kāzeni as one of those who collaborated with Khayyam in establishing this calendar: “It is reported that in the reign of sultan Malekšāh there were a number of sages such as Omar Khayyam and K̄vāja ‘Abd-al-Raḥmān Kāzeni who were instructed by the sultan to make observations in his name. They consulted with each other about this extremely difficult task and after more discussions, they preferred the easier [task] to the difficult one and informed the sultan that ‘it would take at least thirty years to complete the observations Then it would be proper for us ... to make for the sultan a calendar in which the [new] year would always begin at the same time and not change place in the course of time; which would as a result forever keep alive the name of the king’. Upon winning the sultan’s consent, they constructed the aforementioned calendar in sync with the ‘true solar year’ [i.e., tropical year] in the sultan’s name ...” (pp. 21-22).

It seems that as with other observation activities of the Islamic era, a *zij* was compiled as a result of the observations decreed by Malekšāh. This point is likely to be an origin of the scattered references to a *zij* attributed to Khayyam (Ḥāji Kālifā, III, p. 570, called it *Zij-e malekšāhi*). Qoṭb-al-Din, after the aforementioned report, notes that the difference between the true solar year and “365 days” [i.e., the length of normal year], is less than a quarter of a day (according to present-day calculations, it is equal to 0.24222 days, i.e., 5 hours, 48 minutes, and 46 seconds). So the intercalary should be less than one day every four years, and after every six or seven “four years intercalation,” a “five years intercalation” should be considered. And then he mentions, according to his claim, the mistake that occurred in Khayyam’s *Zij* in this case: “... and from what we said, ‘Omar Kāyiyām’s mistake in his *Zij* will appear, where he stated that all intercalations were in the fourth years, but still [the first day of new year] is in sync with the sun reaching the first point of Aries, which is a great error indeed caused by his lack of attention to this detail to



which we have brought your attention” (Qoṭb-al-Din Širāzi, *Eḳtiyārāt-e moẓaffari*, fol. 150r; *al-Toḥfa al-šāhiya*, fols. 131r-131v; *Nehāyat-al-edrāk*, fol. 155r). Such an error, however, seems highly unlikely from a person who, according to Qoṭb al-Din Širāzi himself, was one of the founders of the Jalāli calendar.

Apart from this, Qoṭb al-Din refers to another work by Khayyam, which is a supplementary “chapter” (*faṣl*) that Khayyam has appended (*elḥāqkard-e ast*) to Abu ‘Ali Ḥasan b. al-Hayṭam’s (965-1040) *Treatise on the Movement of Eltifāf* (the movement, or rather change, in the obliquities; Ebn al-Hayṭam’s treatise is not known to have survived). In *Eḳtiyārāt-e moẓaffari* (2nd *maqāla*, 10th *bāb*, fol. 92r), Qoṭb al-Din has only noted this point and, for the text of Khayyam’s chapter, referred the reader to his other work, *Nehāyat al-edrāk fi derāyat al-aflāk* (2nd *maqāla*, 10th *bāb*, fols. 93r-94v). The topic of this chapter was to resolve one of the problems in the Ptolemaic theory of planetary motion. It can thus be considered part of the history of the non-Ptolemaic models in the Islamic world.

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